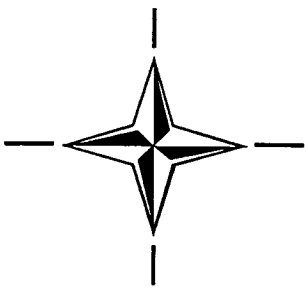
STANAG 4525
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)



NATO STANDARDIZATION AGENCY
(NSA)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: EXPLOSIVES, PHYSICAL/MECHANICAL PROPERTIES, THERMOMECHANICAL ANALYSIS FOR DETERMINING THE COEFFICIENT OF LINEAR THERMAL EXPANSION (TMA)

Promulgated on 25 October 2001

Jan H ERIKSEN
Rear Admiral, NONA
Director, NSA

STANAG 4525
(Edition 1)

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Director, NSA under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "In NATO Standardization, the fulfilment by which a member nation formally accepts, with or without reservation, the content of a Standardization Agreement" (AAP-6).

5. Implementation is "In NATO Standardization, the fulfilment by a member nation of its obligations as specified in a Standardization Agreement" (AAP-6).

6. Reservation is "In NATO Standardization, the stated qualification by a member nation that describes the part of a Standardization Agreement that it will not implement or will implement only with limitations" (AAP-6).

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page (iii) gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page (iv) (and subsequent) gives details of reservations and proprietary rights that have been stated.

FEEDBACK

8. Any comments concerning this publication should be directed to NATO/NSA - Bvd Leopold III, 1110 Brussels - BE.

RATIFICATION AND IMPLEMENTATION DETAILS
STADE DE RATIFICATION ET DE MISE EN APPLICATION

EDITION: 1

NATION	NATIONAL RATIFICATION REFERENCE DE LA RATIFICATION NATIONALE	NATIONAL IMPLEMENTING DOCUMENT NATIONAL DE MISE EN APPLICATION	IMPLEMENTATION / MISE EN APPLICATION					
			INTENDED DATE OF IMPLEMENTATION/ DATE PREVUE POUR MISE EN APPLICATION			DATE IMPLEMENTATION WAS ACHIEVED/ DATE REELLE DE MISE EN APPLICATION		
			NAVY MER	ARMY TERRE	AIR	NAVY MER	ARMY TERRE	AIR
BE								
CA	2441/-4525 (DAPM 4-4) of/du 18.10.00		12.00	12.00	12.00			
CZ	6/2-48/2001-1419 of/du 22.08.01 6/2-18/2000-1419 of/du 26.07.00	Czech Defence Standard No. 137601					10.01	10.01
DA	FKO MAM3 204.69-S4525 0004930-003 of/du 04.09.00		01.02	01.02	01.02			
FR	DGA/INSP Nr 030820 DGA/INSP of/du 7.02.01	AFNOR NF T 70-313	03.01	03.01	03.01	—		
GE	BMVg – Fu S IV 1 – Az 03-51-60 of/du 07.12.00	STANAG	02.02	02.02	02.02			
GR								
HU								
IT								
LU	BO 1654/00 of/du 29.03.00	Not implementing/ Ne met pas en application						
NL	M2001000768 of/du 13.02.01	STANAG				10.01	10.01	10.01
NO								
PL								
PO								
SP								
TU								
UK	D/DStan/12/15/4525 of/du 09/06/00	STANAG	10.01	10.01	10.01			
US	OUSD(A&T) of/du 21.02.00		06.01	06.01	06.01			

* See reservations overleaf/voir réserves au verso

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NAVY/ARMY/AIR

NATO STANDARDIZATION AGREEMENT
(STANAG)

EXPLOSIVES, PHYSICAL/MECHANICAL PROPERTIES, THERMOMECHANICAL ANALYSIS FOR DETERMINING THE COEFFICIENT OF LINEAR THERMAL EXPANSION (TMA)

Annexes:

A. Test Procedure
B. Data exchange format

Related Documents: None.

AIM

1. The aim of this document is to standardize the measurement of the coefficient of linear thermal expansion for explosive materials. The test procedure described in Annex A was developed to provide within NATO a uniform test and with that the information as to how the reported data were obtained.

AGREEMENT

2. Participating nations agree to use the test procedure described in Annex A and to report data using the data exchange format described in Annex B.

IMPLEMENTATION OF THE AGREEMENT

3. This STANAG is considered implemented by a nation when that nation has issued the necessary instructions putting the contents of this agreement into effect.

ANNEX A to
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TEST PROCEDURES

1. Scope

This method is the preferred method for determining the coefficient of linear thermal expansion (α) of solid materials (including the Transition temperature dependence of α). TMA is not the preferred method for determining the Glass Transition Temperature T_g. The Glass Transition Temperature is defined as the temperature where main chain molecular motion ceases, which is not measured in this test.

2. Definitions

a. Linear thermal expansion

Linear thermal expansion is the change in length of a specimen due to a temperature change.

b. Coefficient of linear thermal expansion

The coefficient of linear thermal expansion (α) is defined as the change in length per degree of temperature change divided by the initial length L_0.

$$\alpha(T) = (dL/dT)/L_0$$

The initial length (L_0) is measured at a reference temperature (usually room temperature i.e. 23 ± 5 °C). α is expressed in units of inverse temperature.

3. Test Apparatus

a. Any appropriate equipment may be used, that fulfills the following requirements:

(1) The temperature device shall be able to keep the temperature of the specimen in the range of -100°C to +100°C at a constant value and/or change it at a defined rate. Temperature change shall be slow enough to avoid significant temperature lag in the specimen.

(2) The system for measuring the change in length (e.g. Linear variable differential transformenr LVDT) shall have minimum effect on specimen deformation and it shall be free to follow the change in length of the specimen.

(3) The equipment shall register change in length of the specimen and specimen temperature simultaneously.

Accuracy of measurement: T: $\leq$ 0.2K
L: $\leq$ 0.5µm

b. Each component of the equipment should be calibrated according to the manufacturer's recommended schedule.

4. Specimen

a. Specimen Preparation

Specimen may be produced directly by casting, pressing, or may be machined from bulk material. The surface of the specimen should be smooth.

b. Specimen Shape

The shape of the specimen depends on the equipment used. A typical specimen is a cylinder with 10 mm length and 10 mm diameter. Specimen ends shall be flat, parallel within 5% of the original width and perpendicular to the longitudinal axis.

c. Number of specimens

For an isotropic material at least three specimens have to be measured, for an anisotropic material at least three specimens in each direction.

d. Specimen Preconditioning

Before the test, specimen shall be preconditioned for 24 hours at 23 ± 5 °C at a selected level of relative humidity (material dependent).

5. Test Method

a. Preparing the test

(1) With this test the reversible thermal expansion of the tested solid material shall be measured. Irreversible thermal expansion (for example change in moisture content, loss of plasticizer or solvents) should be excluded (if possible).

(2) The initial length of the specimen L_0 is measured at reference temperature at the centre of the specimen. The accuracy should be better than one percent of the initial length. When the specimen is put in the apparatus, care shall be taken that the longitudinal axis of the specimen is aligned with the axis of the apparatus. For probe contact, the contact force should be carefully selected and evaluated to minimize indentation or creep during the test.

b. Running the test

(1) The conditioning chamber is cooled down to 10 K below the lowest desired temperature. The temperature is kept constant for sufficient time to ensure that there is no temperature gradient in the specimen. The specimen is then heated up continuously or in a stepwise fashion while the change in length and temperature are registered. The temperature change shall be slow enough, to ensure that the specimen has the same temperature over the whole volume.

(2) The direction of temperature change is normally not expected to influence the coefficient of linear thermal expansion. Therefore, the test may also be conducted beginning with the highest temperature and cooling during the test. However, there might be explosives where the measurement of the coefficient

of linear thermal expansion at temperatures below 100 °C may be influenced by specimen softening, crystallization, or phase change. (see cautions).

(3) After the runs the length of each test specimen shall be measured at reference temperature. A change in length is indicative of an irreversible process having taken place. If this has occurred a second run should be conducted with at least one of the initial specimens.This second run should not be used to calculate $\alpha(T)$. If there is a large deviation in the results compared to the first run, this indicates irreversible processes. The occurence of irreversible processes shall be noted.

6. Data Reduction

a. Determination of α

From the measured temperature and elongation values the coefficient of linear thermal expansion can be calculated as:

$$\alpha(T) = (dL/dT)/L_0$$

The results are plotted as $L(T)/L_0$ versus T or as $\alpha(T)$ versus T.
Since the procedure for data reduction often depends on the equipment, a general prescription for data reduction cannot be given.

b. Report

The report shall include sufficient information to complete the Data Exchange Format, any information about irreversible processes, $\alpha(T)$, and a plot of $\Delta L(T)/L_0$ vs T or $\alpha(T)$ vs T. Temperatures of all slope breaks shall be listed.

7. Cautions

a. The measurement of the coefficient of linear thermal expansion may be influenced by specimen softening, crystallization, or phase change. The direction and the rate of temperature change shall be chosen carefully.

b. Any irreversible change in specimen dimension shall be reported.

DATA EXCHANGE FORMAT
Thermomechanical Analysis

Report Reference Number:

Page___of___Pages

TEST SITE INFORMATION

Laboratory:

Date:

Test Procedure: Thermomechanical Analysis

AOP-7 Test Procedure Number: 102.01.060

Date Tested:

TEST CONDITIONS

Initial Temperature (K):

Final Temperature (K):

Temperature Rate (K/min):

Machine Type:

Probe Mass (g):

Probe Type:

SPECIMEN INFORMATION

Dimension: (mm) Length:
Width:
Thickness (Diameter):
T (K):

Form:

Preparation Method:

Manufacturing Method:

Source:

Lot or ID Number

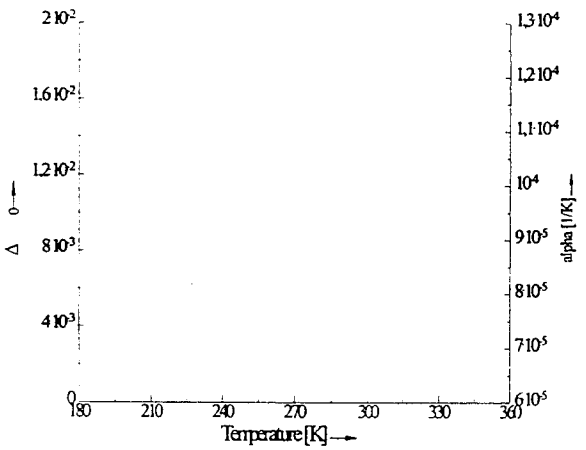
Preconditioning:

Conditioning Period:

Composition:

Component	Percent
_____	_____
_____	_____
_____	_____
_____	_____

Results



T (K)	ΔT (K)	$\Delta L/L_0$ (10^{-3})	α ($K^{-1}.10^{-6}$)	Comments:

Data Sent To:

α = <T>

ANNEX B to
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DATA EXCHANGE FORMAT
Thermomechanical Analysis

Report Reference Number: (*instruction sheet*)

Page___of___Pages

TEST SITE INFORMATION

Laboratory: *(Name of Laboratory)*

Date: *(Date that Form was Completed)*

Test Procedure: Thermomechanical Analysis

AOP-7 Test Procedure Number: 102.01.060

Date Tested: *(Date of Test)*

TEST CONDITIONS

Initial Temperature (K): *(Initial SpecimenTemperature)*

Final Temperature (K): *(Final Specimen Temperature)*

Temperature Rate (K/min) *(Heating Rate)*

Machine Type: *(Name and Model No. of Machine)*

Probe Mass (g): *(Total mass acting on Probe)*

Probe Type: *(Name and Model No. of Probe)*

SPECIMEN INFORMATION

Dimension: (mm) Length: *(Specimen length)*
Width: *(Width and Thickness or Diameter)*
Thickness (Diameter):
T (K): *(Temperature of Specimen at L_0)*

Form: *(Specimen Geometry Descriptor)*

Preparation Method: *(Specimen Preparation Procedure)*

Manufacturing Method: *(Specimen Processing Technique)*

Source: *(Name of Manufacturer)*

Lot or ID Number *(Same as on Material Description Sheet)**

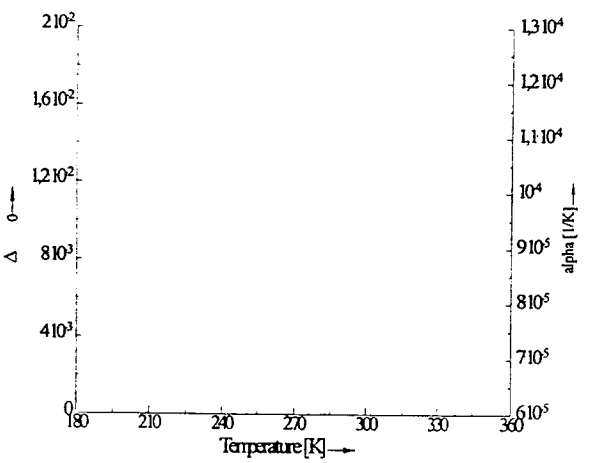
Preconditioning: *(Specimen Preconditioning Descriptor)*

Conditioning Period: *(Period Specimen was Conditioned)*

Composition: *(Specimen Name)*

Component	Percent
_____	_____
_____	_____
_____	_____
_____	_____

Results



(Scale Axis)

T (K)	ΔT (K)	$\Delta L/L_0$ (10^{-3})	α ($K^{-1}.10^{-6}$)	Comments:
(Specimen Temperature)	*(Specimen temperature Change)*	*(Specimen Normalized Change of Length)*	*Coefficient of Linear Thermal Expansion)*	*Explain or Comment all Slope Breaks* *(Any information not available = NA)* *(Entries may be typed or handwritten)* ** If the specimen has been conditioned in any way that makes them different from those usually indicated by this Lot or Identification Number, add a suffix to the Lot or ID Number to indicate this difference, e.g. if Lot RAD 980522 was aged 30 days at 60°C it could be written as RAD980522-30D60C*

Data Sent To:
(Name and address of Person receiving this Information)

α = *(Average Coefficient of Linear thermal Expansion)* <T> *(Indicate the Range of Temperature over which α is a Good Value)*

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DATA EXCHANGE FORMAT
Thermomechanical Analysis

Report Reference Number: Example Nr. 1 *(sample sheet)* Page___of___Pages

TEST SITE INFORMATION

Laboratory: WIWEB GERMANY

Date: 27/10/1999

Test Procedure: Thermomechanical Analysis

AOP-7 Test Procedure Number: 102.01.060

Date Tested: 20/10/1999

TEST CONDITIONS

Initial Temperature (K): 173

Final Temperature (K): 353

Temperature Rate (K/min) 2

Machine Type: Netsch TMA 402

Probe Mass (g): 2

Probe Type: quartz cylinder ∅ 3mm, tip rounded

SPECIMEN INFORMATION

Dimension: (mm)
Length: 10
Width: 8
Thickness (Diameter): 8
T (K): 293

Form: cylinder

Preparation Method: machining

Manufacturing Method: casting

Source: Raufoss

Lot or ID Number NA

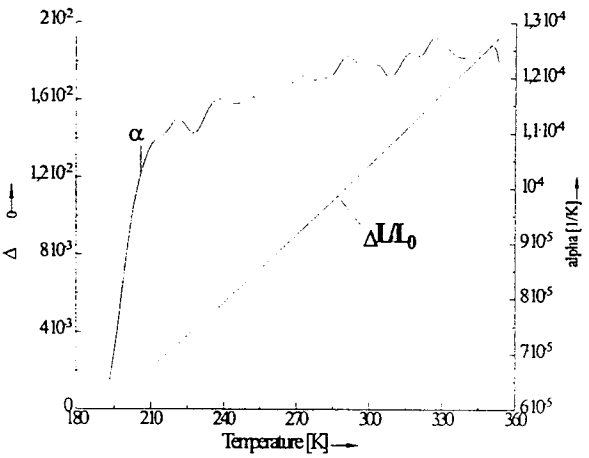
Preconditioning: NA

Conditioning Period: 3 days silicagel

Composition: Propellant

Component	Percent
NH_4ClO_4	75.1
HTPB	18.0
Oxamid	5,8

Results



T (K)	ΔT (K)	$\Delta L/L_0$ (10^{-3})	α ($K^{-1}.10^{-6}$)
250	0	6.64	116.2
260	10	7.80	117.5
270	20	8.99	119.8
280	30	10.2	119.7
290	40	11.4	123.8
300	50	12.6	121.8
310	60	13.8	120.6
320	70	15.1	123.9

Comments:

Data Sent To:

α = $121 * 10^{-6} K^{-1}$ 280 K<T> 320 K